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RIPENING AND DISPERSAL OF A BUMPER WESTERN HEMLOCK-SITKA SPRUCE SEED CROP IN SOUTHEAST ALASKA

by

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ABSTRACT

During a bumper seed year, a mature western hemlock-Sitka spruce stand in southeast Alaska produced 131 pounds of seed per acre, 63 percent of which was sound. Seed was dispersed over a 1-year period beginning on October 22, with cone scales opening and closing in response to moisture, and seedfall increased by wind. Information on cone condition, seed ripening, and weather conditions associated with seed dispersal is given.

Western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) and Sitka spruce (*Picea sitchensis* (Bong.) Carr.) together comprise about 92 percent of the commercial timber volume in southeast Alaska. Both species are prolific seed producers, with at least some seed produced almost every year and a heavy crop every 5 to 8 years. Seed dispersal from the heavy cone crops of 1951 and 1959 and from the medium cone crop of 1956 has been reported (Godman 1953; Harris 1967; James 1959).[1/] In 1966, a bumper cone crop occurred, offering an opportunity to obtain more detailed information about seed maturation and its dispersal.

1/ Names and dates in parentheses refer to Literature Cited, page 11.

Seeds of both hemlock and spruce are small, hemlock averaging 297,000 seeds per pound and spruce 210,000 seeds per pound (U.S.D.A. Forest Service 1948). Seeds of both species have large wings for their weight and are carried great distances by the wind. This has led to the practice in southeast Alaska of clearcutting timber in blocks up to a mile square and relying on natural seedfall to restock the cuttings. Reliance on natural regeneration, seed collecting for provenance testing, and the expectation of future intensive silviculture led us to this investigation of seed production and dispersal.

METHODS

The study was done in an old-growth, western hemlock-Sitka spruce stand located 4.5 miles northwest of Juneau, Alaska. Timing and amount of natural seedfall was determined from four seedtraps, each 2 by 3 feet in size, located in a line 2 chains apart beneath the timber stand. The stand, as characterized by a circular 1/5-acre plot surrounding each seedtrap, averaged 88 trees per acre. Average tree diameter at breast height was 21 inches, ranging from 8 to 40 inches. Dominant trees were 130 feet tall. Basal area was 248 square feet per acre, and species composition by basal area was 74 percent hemlock, 26 percent spruce.

Seedtraps were inspected daily from October 1966 through January 30, 1967, then monthly or intermittently through December 1967. Muslin liners were removed at each inspection and seed were counted. A cutting test was made to determine seed soundness at monthly intervals.

For determining when seed ripened (matured), cones were collected from one mature spruce and one mature hemlock tree at weekly intervals from July 30 to October 15, 1966. Cones were collected from the top one-third of tree crowns by use of 40-foot aluminum ladders attached to the boles for easy access to branches. Three to five cones were dissected immediately after collection. Cone scale color and seed color, interior consistency, and wing condition were described.

Ten spruce and 20 hemlock cones were measured, then air-dried at room temperature immediately after collection. Seed was extracted and stored dry at 40° F. until all collections had been completed. In most cases, cones opened from one to several days after drying began, and seed was easily shaken out. However, both the hemlock and spruce cones collected on July 30 failed to open and had to be cut apart to remove seed. Viability was then determined from germination tests of four lots of 50 seeds each.

On January 31, seeds were placed on germination pads in covered petri dishes and maintained at 75° to 80° F. and 12-hour-day light periods until April 26. A seed was considered to have germinated when the radicle emerged.

Weather data for the general area was obtained from published records of observations made at the ESSA-Weather Bureau Office at the Juneau Municipal Airport, located 3.5 miles northwest of the study area.

RESULTS

Seed Ripening

Germination tests showed that some spruce seed was mature enough to germinate by August 6 and viability increased abruptly during the week of August 13-20. Maximum maturity appears to have been reached by September 3 with no increase thereafter, although test results were erratic. Spruce seed began to mature when about 1,000 degree-days[2/] had accumulated (fig. 1). Greatest increase in maturity occurred between 1,000 and 1,400 degree-days.

Hemlock seed began to mature by August 13, but showed little increase until the week of September 10, when germination percent surged sharply. Thereafter, more seed appeared to mature through October 16, the end of the sampling period, although again germination results were erratic. Hemlock seed began to mature when about 1,100 degree-days had accumulated, but the first substantial increase occurred after 1,300 degree-days and continued to increase until the season's total of 1,595 degree-days had accumulated.

Gross physical appearance of freshly collected cones and seed were noted during ripening (table 1). In the case of spruce, 48-percent germination was obtained from seed collected by August 20. At this time seedcoats were still cream colored and the "endosperm" (megagametophyte tissue plus integuments) soft. This was fully 6 weeks before seed took on the characteristic dark chocolate-brown color and endosperm assumed the firm consistency of maturity. Regression analysis showed that spruce cones increased in length only slightly during the collection period, from an average of 61.3 millimeters on July 30 to 66.5 millimeters on October 16.

Hemlock began to ripen abruptly 3 weeks later than spruce, the first substantial change occurring during the week preceding September 10, when average germination was 36 percent. At this time, seedcoats

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[2/] As defined here, one growing degree-day is accumulated for each 1° F. rise in temperature above a daily mean of 41° F. (5° C.). For example, if the daily mean is 51° F., 10 growing degrees would be accumulated for that day.

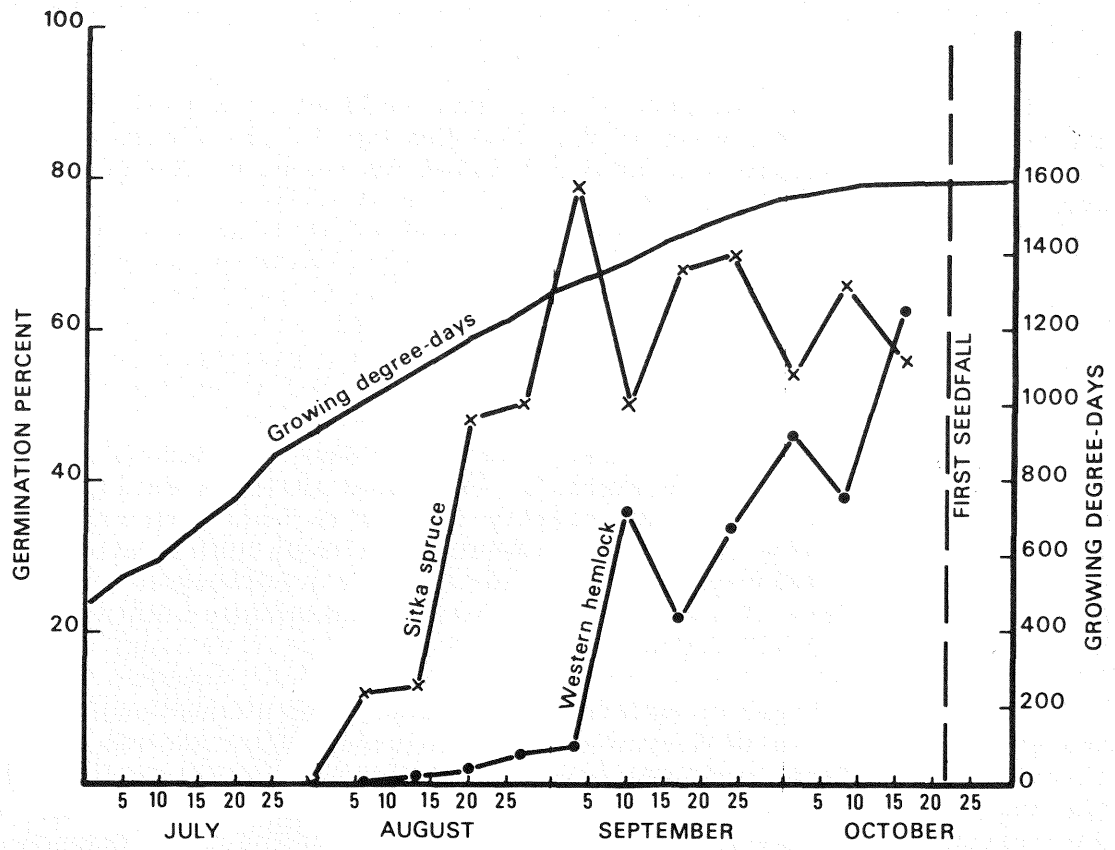

Figure 1.—Ripening of western hemlock and Sitka spruce seed collected at weekly intervals, Juneau, Alaska, 1966.

were cream colored, the wing still fragile and adhering to cone scales, and endosperm soft. Cones were tightly closed and still green. Seed did not take on the characteristic light-brown color and endosperm the firm consistency of maturity until October 8-16, only 2 weeks before seed began to fall. Hemlock cones increased in length only slightly, from an average of 16.8 mm. on July 30 to 18.0 mm. on October 16. Differences in seed ripening between trees is likely. However, samples were obtained from only one tree of each species, so no measure of variation was obtained.

Time of Seed Dispersal

In the case of both hemlock and spruce, a common observation is that cone scales open upon drying, thus releasing seed. This process was amply demonstrated. After cones matured, they opened in response to dry atmospheric conditions and reclosed in wet conditions (fig. 2).

Table 1.--*Physical condition of western hemlock and Sitka spruce cones and seed during ripening, Juneau, Alaska, 1966*

Collection date	Cumulative degree-days (base 41° F.)	WESTERN HEMLOCK					SITKA SPRUCE				
		Germination percent	Cone scale color	Seed wing	Seedcoat	Seed contents	Germination percent	Cone scale color	Seed wing	Seedcoat	Seed contents
July 30	924	0	--	--	--	--	0	--	--	--	--
August 6	1,014	0	Green; purple edge; purple cone tip	Light green; transparent; adheres to scale	Pale green; soft	Liquid; milky	12	Pale green; purple tip	Red purple	Pale green to cream; soft	Soft; milky
August 13	1,094	1				Soft; not milky	13			Cream; soft	Soft; not milky
August 20	1,168	2					48	Pale green to tan; purple tip		Cream; firm	
August 27	1,255	4			Pale green to cream; soft		50			Cream to gray white; firm	Soft; pastelike
September 3	1,321	5		White; transparent; adheres to scale	Pale green to cream; firm		79			Light tan; crisp	Firm; pastelike
September 10	1,378	36	Green; red-brown edge; purple cone tip	White to cream; adheres to scale			50			Tan; crisp	
September 17	1,458	22				Soft; pastelike	68		Purple red		Firm
September 24	1,502	34	Green to tan; red-brown edge; brown cone tip			Firm; pastelike	70	Tan to light brown; dull purple tip	Purple	Light brown to dark brown; crisp	
October 1	1,556	46		White to cream; easier to separate from scale			54	Light brown; faded purple tip	Purple brown	Dark chocolate brown; hard	
October 8	1,587	38	Green to brown; red-brown edge; red-brown cone tip	Tan or light brown; separates easily from scale	Cream to tan; firm	Firm	66				
October 16	1,595	63			Light brown to brown; firm		56		Purple brown to brown		

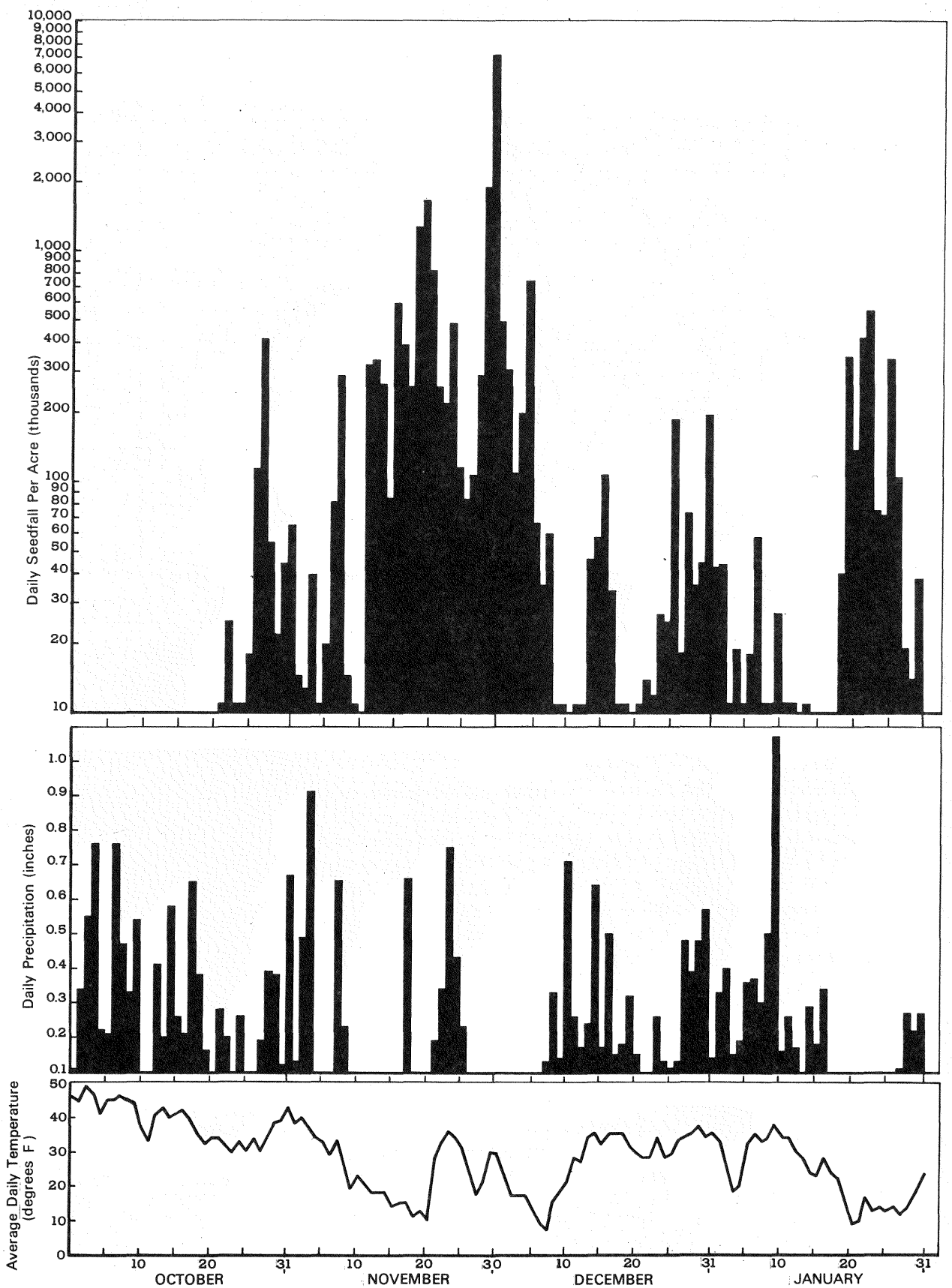

Figure 2.—Daily western hemlock and Sitka spruce seed dispersal, October through January 1966-67, Juneau, Alaska.

The first seeds fell on October 22, the second successive dry day following a week of rain. After this, seedfall was roughly correlated with dry weather and wind; that is, dry weather caused cone scales to open and wind helped to dislodge seeds. This process was evident from the number of seed falling daily. However, seedfall and precipitation as shown here do not correlate exactly because of several complicating factors:

1. Cones sometimes remained closed during days or part of days when no precipitation occurred, especially when cool, cloudy weather followed a period of heavy rain. Also, when dry, freezing weather immediately followed rain, saturated cones froze, and ice effectively held cones closed for a longer time than usual.

2. Because of the time lag in closing in response to moisture, cones often remained open for part of a day in which some precipitation fell. Such a change in weather pattern was usually accompanied by strong southeast winds.

3. During generally dry, freezing periods, a small amount of precipitation in the form of snow did not cause cones to close.

The general pattern of seedfall showed that cones opened during dry, windy weather. Cones opened and closed many times during the fall and winter, and many flexings of scales occurred before all seeds were dislodged.

Seed was dispersed over a 1-year period. During the 4 months (October-January) when seedfall was observed daily, at least 300,000 seeds (roughly 1 pound per acre) fell on 18 separate days. Greatest seedfall took place on November 30, when slightly over 7 million seeds (nearly 26 pounds) per acre fell. This seedfall, along with that which built up successively during 5 previous clear days, fell on crusted snow, and we received many reports of the tremendous number of seeds covering the snow. It was possible at this time to literally scoop up seed by the handful in depressions where it had been blown by the wind.

From October through January, most seed was dispersed when prevailing local winds were easterly (fig. 3). The largest percentage of seed (37 percent) was dispersed on days when the prevailing wind direction was from the southeast (110°). Next, 18 percent was dispersed when wind was from 80°, and 15 percent from 30°. During the fall and winter, dry weather in southeast Alaska is usually associated with general air movement from the interior located to the northeastward, and influenced greatly by local topography.

The bulk of spruce seed fell earlier than hemlock (fig. 4). By November 30, 73 percent of spruce seed had fallen compared with 45 percent of the hemlock seed. Both species retained some seed for over 1 year, the last dispersed in late October of 1967.

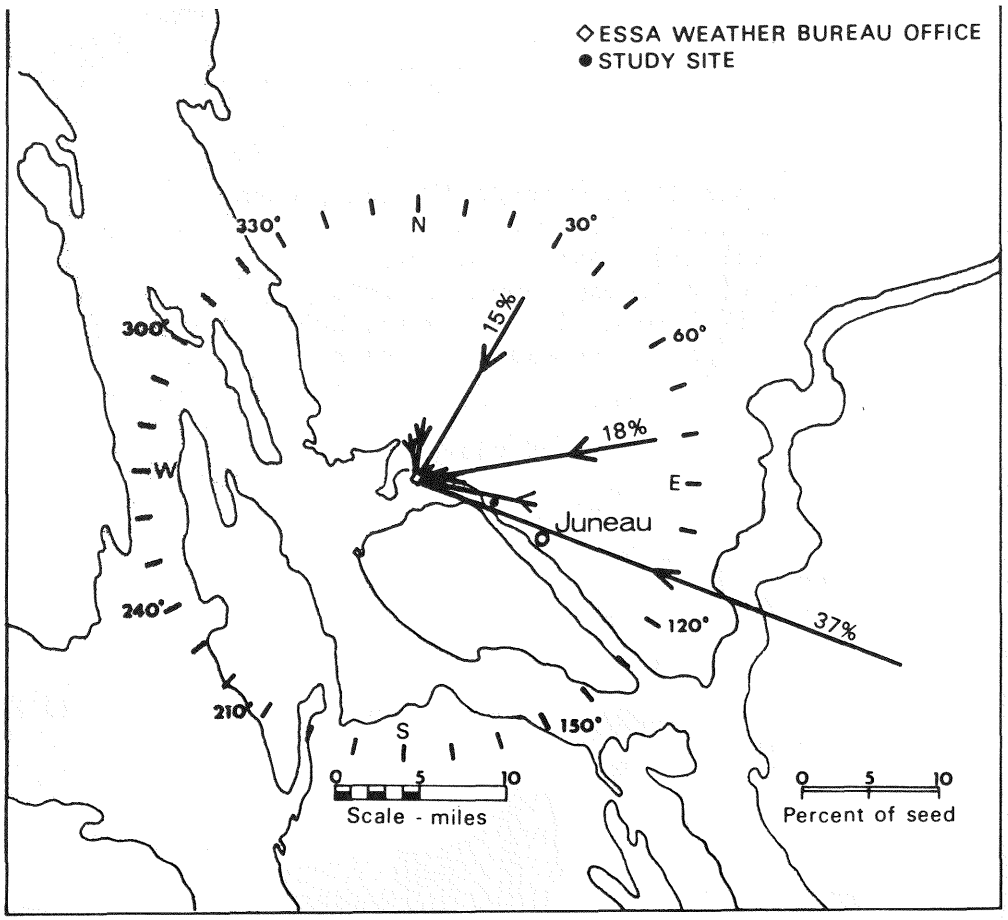

Figure 3.—Percentage of seed dispersed on days with prevailing wind direction indicated (length of vector line indicates percentage of seed dispersed). Juneau, Alaska, 1966-67.

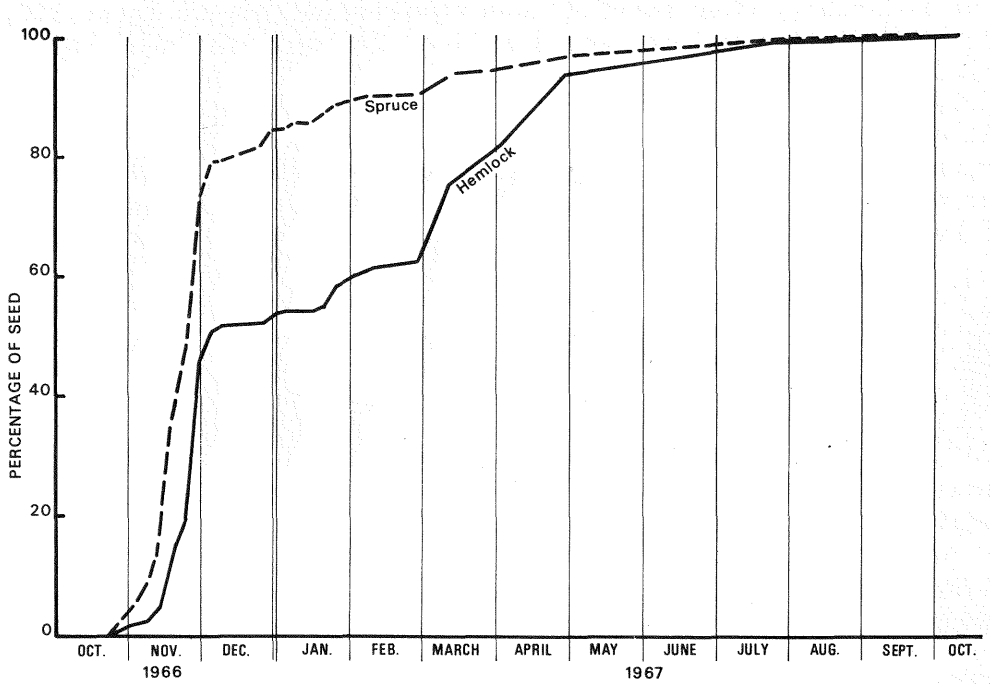

Figure 4.—Cumulative dispersal of western hemlock and Sitka spruce seed by date, Juneau, Alaska, 1966-67.

Total Seed Production

Total seed production of the stand averaged 37,195,000 seeds per acre, with the true average somewhere between 33,543,000 and 40,846,000 seeds per acre unless a 1-in-20 chance in sampling occurred. By weight this is equivalent to approximately 131 pounds per acre, the true average being between 118 and 144 pounds; 89 percent of this was western hemlock, 11 percent Sitka spruce.

Percentage of sound seed decreased during the period of dispersal (fig. 5). These percentages, applied to the amount of seed dispersed by date, indicated total sound seed produced by the stand averaged 20,380,635 hemlock and 2,742,465 spruce seed per acre, an average of approximately 82 pounds of sound seed per acre.

Seed soundness (fig. 5), as determined by cutting tests, suggested that the percentage of filled seeds remained fairly stable through January, then decreased, although test results were erratic. During the ripening period, seed soundness generally followed the pattern of germination test results but was consistently higher.

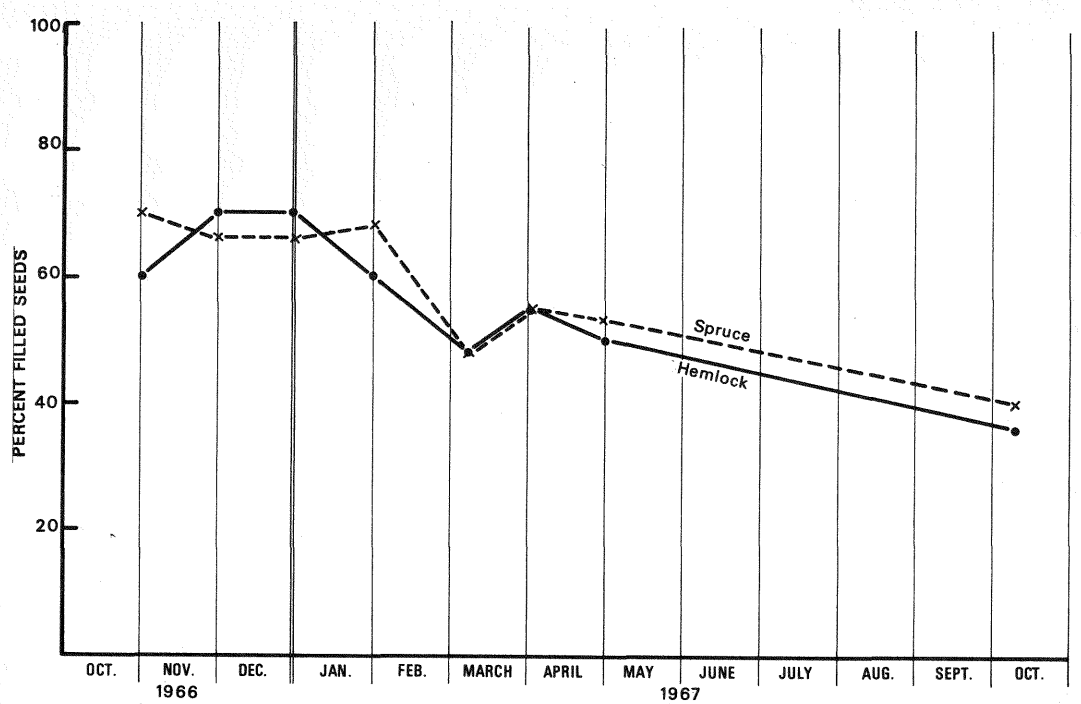

Figure 5.—Seed soundness by collection date, Juneau, Alaska, 1966-67.

CONCLUSIONS

Both hemlock and spruce are prolific seed producers. During the heavy seed year of 1966-67, a mature timber stand produced an average of 131 pounds of seed per acre. Soundness decreased with time of dispersal, averaging 63 percent sound by cutting test.

Sitka spruce seed ripened 2 to 3 weeks earlier than western hemlock. Seed of both species was mature enough to allow cone collecting by mid-September and immediate drying and seed extraction. Work with Douglas-fir has shown that seed continues to ripen in cones stored under cool, damp conditions (Silen 1958; Rediske 1961). If afterripening occurs in hemlock and spruce, the cone collecting period may be similarly extended.

Seed color offered a conservative indication of maturity but failed to indicate clearly when seed first matured. Investigations by Sarvas (1967) in Finland have shown striking relationships between temperature sums and the course of annual physiological events of forest trees, especially with respect to anthesis. A method of temperature summation, such as that expressed by degree-days, may eventually offer an indication of when seed is mature, but much work will be needed before it is reliable. The temperature summation presented here is offered as a rough model only.

Once ripe, seed remained in closed cones on the trees until sufficiently dry weather occurred. Timing of seedfall depends on weather conditions, and each year may provide a different pattern. For example, in 1966, as reported here, the first seed fell on October 22. This is comparable to 1956, when James (1959) reported that no spruce and less than 2 percent of hemlock fell before October 25. This date is some 2 weeks later than the October 6 date reported for 1959 (Harris 1967) and a month later than the September 21-28 date reported for 1951 (Godman 1953).

Seed was released over a period of many months, with cone scales opening and closing in response to moisture and seedfall increased by wind. Many flexings of cone scales occurred before all seeds were dislodged.

Wind direction during dry weather, when cone scales open, was generally northerly or easterly and much seed was shed at these times. However, strong southeast winds often preceded autumn and winter storms, and seed was dispersed before cone scales closed in response to increased moisture content. Winds are strongly affected by mountains so that local topography must be considered when attempts are made to draw general conclusions about the direction of seed dispersal in southeast Alaska.

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